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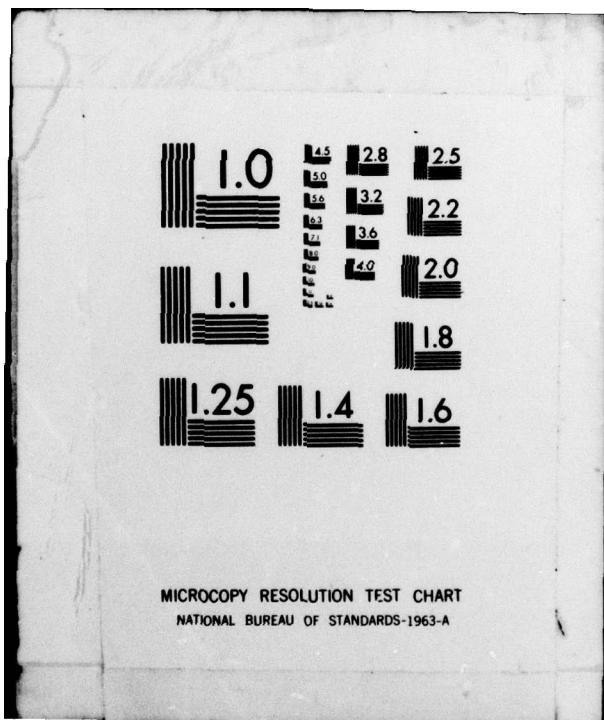
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Technical Memorandum No. 70

SOME COMMENTS ON THE SENSITIVITY OF  
THEORETICAL AND EXPERIMENTAL RESULTS

by

Melvin Klerer

February 4, 1963

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During his excellent presentation of February 1, 1963, C. S. Clay  
briefly touched upon the subject of the sensitivity to a change of parameters  
displayed by both the theoretical and experimental results for the acoustic  
propagation problems, usually considered by this laboratory. In the  
past, numerous other people here have commented on this phenomenon.  
As I have heard it, the consensus of opinion may be expressed by the  
declarations:

- 1) "Theory" and experimental results are sensitive to  
a change in parameters, e. g., source depth, receiver  
depth, frequency, etc.

and

- 2) "Theory" and experimental results are equally sen-  
sitive.

I have no quarrel with assertion 1). However, I have long had my  
doubts about the correctness of assertion 2).

Recently I resumed in an expanded and detailed manner some  
"Ray-Theory" (Geometrical Optics) type calculations, first done some  
years back. As a by-product of my present calculations, I have had the  
chance to verify, in a precise manner, my earlier thoughts on the possible  
inadequacy of assertion 2).

One of the things done so far is to compute the pressure, due to  
coherent interference of multipaths, for interesting ranges and depths.  
The results of one such set of calculations was compared to the results

produced by a normal mode program of Tolstoy and May.<sup>1</sup> We were interested in the sensitivity as a function of receiver depth. The identical model was used in both calculations, and there was no reason, on physical grounds, to suspect that the selected depths (1400 to 1500 ft) or the selected range (40 to 80 nautical miles) lay in a particularly unstable region of what was a very simple 3-layer model of the deep ocean. The frequency was chosen to be low (10 cps) so that the depth variation (100 ft) was of the order of 1/5 of the basic cw wavelength.

One of the "indices of sensitivity" that we used was simply the distance between successive peaks of the envelope of pressure as a function of range  $\equiv L$ .

For this case we noted:

a) The rate of change of  $L$  with depth for the RT ("Ray-theory") calculation was of opposite sign to that of the NM (normal mode) calculation.

b) 
$$\frac{\left( \frac{\Delta \bar{L}}{\Delta D} \right)_{RT}}{\left( \frac{\Delta \bar{L}}{\Delta D} \right)_{NM}} \approx - .385 ,$$

where the bar denotes an average over range and  $D$  is the depth.

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<sup>1</sup> Ivan Tolstoy and Jack May, "A numerical solution for the problem of long-range sound propagation in continuously stratified media with applications to the deep ocean," J. Acoust. Soc. Am. 32, 655-660 (1960).

c) The relative change of  $\bar{L}$ , i.e., 
$$\left\{ \frac{\bar{L}_{1500} - \bar{L}_{1400}}{\frac{1}{2}(\bar{L}_{1500} + \bar{L}_{1400})} \right\}$$

was + 12.3 percent for RT but was -40.5 percent for NM, giving an overall difference of ~53 percent in relative change between the two calculations.

So far we have made this comparison for only one type of situation. If further study does not emasculate these figures, then we would come to the conclusion that

- I There is a sharp difference in the sensitivity predicted by these two "theories."
- II The difference is so sharp that a (conceptually) simple experiment can easily decide which "sensitivity" is closer to the real world.
- III Because of I), a fit of "theory" to experiment cannot be expected to agree in a detailed fashion, yet the contrast between the two calculations is great enough so that it is easy to make a statistically significant choice between the two numerical programs.
- IV That irrespective of theoretical arguments, the actual sensitivity of propagation to change in physical parameters has not been elucidated and what is wanting is reliable experimental results and meaningful analyses of same.

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